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RESEARCH INTO TELECONFERENCING

DECISIONS AND DESIGNS INCORPORATED

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Gregory M. Hunter
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by

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Video teleconferencing offers potential to reduce costs involved in bringing individuals from distant locations together for a conference. A teleconference system connects several sites by video, audio, and/or data channels. This report describes research by Decisions and Designs, Inc. (DDI) involving the design, construction, demonstration and evaluation of a video teleconference system that enhances the communication capability available with current systems. Specifically, the system provides for: natural connection of more

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than two sites, use of existing communications skills, and real-time examination of pictorial information, such as graphical displays and briefing charts, and other data.

Current teleconference systems have not been successful, in part, for the following reasons: (1) there is great difficulty in connecting more than two teleconference sites; (2) video teleconferencing requires the use of communication skills which may be unfamiliar to the conferees; and (3) current video teleconference systems present distorted representation of the spatial arrangement of the conferees and, consequently, do not provide for adequate communication of nonverbal cues.

Enhanced communication capability is obtained by using a technique developed at DDI called "Virtual Space," which produces a simulation of the spatial relationships among the participants of a face-to-face conference by giving the conferees the ability to maintain eye contact and observe the direction of gaze of other conferees. The increased realism of Virtual Space is produced by the following three factors: the arrangement of the monitors is the same as an arrangement of people which may occur at a traditional meeting; the arrangements at each teleconference station are consistent with a single spatial representation; and multiple cameras at each station give each participant the same view of each other conferee that he might have in a face-to-face conference.

To evaluate the Virtual Space technique, DDI built a Virtual Space teleconferencing system connecting four offices. Graphical data are displayed to conferees on a shared graphical work space monitor, which integrates inputs from an overhead camera at each station with the output of a video disk. The system has been demonstrated to a large number of individuals from both the military and business communities, and responses have been favorable. Recommendations for future research are included in this report.

SUMMARY

Video teleconferencing is a way to hold meetings among individuals in distant locations without travel. A teleconference system connects several sites by video, audio, and/or data channels. This report describes research by Decisions and Designs, Incorporated (DDI) involving the design, construction, and evaluation of a video teleconference system that enhances the communication capability available with current systems. Specifically, the system provides for:

- natural connection of more than two sites;
- use of existing communications skills; and
- real-time examination of pictorial information and other data.

Enhanced communication capability is obtained by using Virtual Space, a technique producing a simulation of the spatial relationships among the participants of a face-to-face conference. The increased realism of Virtual Space is produced by three factors. First, the arrangement of the monitors is the same as an arrangement of people which may occur at a traditional meeting. Second, the arrangements at each teleconference station are consistent with a single spatial representation. Finally, multiple cameras at each station give each participant the same view of each other conferee that he might have in a face-to-face conference.

Virtual Space extends the capability of current teleconference systems by giving the conferees the ability to maintain eye contact and observe the direction of gaze of other conferees. It is hypothesized that this capability

creates a teleconference environment more similar to a face-to-face conference. Consequently, Virtual Space is expected to be more readily accepted than existing teleconference systems.

In order to determine the benefits and drawbacks of Virtual Space teleconferencing and to demonstrate the feasibility of the concept, DDI built a Virtual Space teleconferencing system. Four interconnected offices were supplied with teleconference stations tailored to the requirements of office size, as well as to the preferences of the station users. Graphical data are displayed to conferees on a shared graphical work space monitor, which integrates inputs from an overhead camera at each station with a video disk.

The system has been demonstrated to a large number of individuals from the military and from industry. Responses have been favorable and indicate that Virtual Space provides a realistic simulation of a face-to-face conference. DDI has completed a detailed evaluation which indicates that video teleconferencing with Virtual Space provides nearly as good overall performance as a face-to-face conference and is especially effective for ad hoc meetings and for meetings addressing internal problems.

Three avenues for future research were identified. First, methods to maintain conference realism while increasing security should be investigated. Since compression of the bandwidth for video data is necessary for encryption, methods of bandwidth compression providing for the most realistic conference must be found. Second, the resolution of the shared graphical work space must be increased, and additional sources of data must be integrated into the system. These improvements in capabilities will necessitate shifting control of some features from the principal conferee to an assigned staff. Finally, the system should be enlarged to include more sites and more conferee surrogates within a site.

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RESEARCH INTO TELECONFERENCING

1.0 INTRODUCTION

This report describes the results of research by Decisions and Designs, Incorporated (DDI) to design, build, and evaluate a video teleconference system that enhances the communications available with current systems. The remainder of this section introduces the problem and briefly describes the solution concept, which has been named Virtual Space. Section 2.0 discusses some of the benefits which might be brought about by Virtual Space. Section 3.0 describes the facility which is currently being used for demonstrations and conferences at DDI, and Section 4.0 gives the results of an evaluation of the effectiveness of the system. Finally, Section 5.0 discusses the conclusions of the research and outlines recommendations for future research in video teleconferencing. In addition to research on teleconferencing, work was performed on technology transfer; this work is summarized in Appendix A.

1.1 Teleconference Background

Often, high-level decision makers from different organizations must meet to coordinate and set policy. Delay in assembling representatives from different locations costs personnel time, lost opportunity, flexibility in high-level schedules, and decision timeliness. In addition, travel time may be an inefficient use of personnel time and may delay action; fatigue may reduce personnel effectiveness.

Video teleconferencing offers a mechanism to avoid the high costs of meetings among individuals in different locations. A teleconference system connects several sites by video, audio, and data channels. Each participant in a teleconference views other participants on TV monitors; voices are transmitted over the audio channels. The data channel may provide information from a variety of sources including computer programs, video disks, digital input from data tablets, and video images of pictures, notes, and so forth.

Video teleconferencing is hardly a new technology. Pye and Williams (1977) report the existence of a video teleconference system as early as 1935. However, the concept is receiving new impetus due to the introduction of improved satellite communication and fiber optics technologies. In addition, the need for government organizations and multinational corporations to communicate over large distances has generated new demand for teleconference systems.

Although teleconferencing offers great potential to reduce the costs and increase the productivity of meetings among distant participants, it has not been used extensively. The low use of teleconferencing has been noted by Johansen, Vallee, and Spangler (1978), who suggest that it is caused by the difficulty involved in connecting more than two teleconference sites simultaneously, combined with the new communications skills required for communication on teleconference systems. Hunter (1980) hypothesizes that these differences are due in part to the inability of current teleconference systems to represent faithfully the spatial relationships which occur among the participants of a face-to-face conference.

Associated with the representation of spatial relationships is the ability to establish eye contact and to communicate other nonverbal information. Nonverbal cues have been shown to have several functions in interpersonal communication (See Argyle and Cook, 1976; and Duncan, 1969). We use eye motions to direct our own attention selectively but, in doing so, we also provide information to others who may be watching concerning the locus of that attention. Especially strong is the effect of eye contact between two conference participants who acknowledge that each of them knows he has the other's attention. Gestures such as finger-pointing may be used to direct the attention of others to some area of interest. Posture, orientation, and involuntary actions may provide information about a conferee's overall state of arousal or interest in the proceedings, or about his reaction to a particular speaker or idea.

Certain gestures work only if they can be visually addressed to individuals. Many of the above fall into this category, and therefore cannot be used to maximum advantage in current teleconference systems which do not transmit clear information about orientation, pointing, angles, and so forth.

In summary, video teleconferencing offers potential to reduce the costs involved in bringing individuals from distant locations together for a conference. However, current teleconference systems have not been successful, in part, for the following reasons:

- There is great difficulty in connecting more than two teleconference sites.

- Video teleconferencing requires the use of communication skills which may be unfamiliar to the conferees.

- Current video teleconference systems present a distorted representation of the spatial arrangement of the conferees and, consequently, do not provide for adequate communication of nonverbal cues.

1.2 Purpose of the Present Research

The purpose of this research is to design, develop, implement, and evaluate a video teleconference system which avoids the failures of currently available systems. Specifically, this system should provide for:

- Natural connection of more than two sites.
- Usage of existing or easily obtainable communication skills.
- Real-time examination of pictorial information and other data.

The goal of this project is a video teleconference system which provides a realistic simulation of a face-to-face conference. The simulation should provide for communication of the large number of nonverbal visual cues which are commonly used to express opinions and to control the direction taken by a face-to-face conference. The participants of such a teleconference should, as much as possible, have the impression of being around an actual conference table interacting with other individuals.

In addition, the participants in a teleconference should be able to share a large variety of data. These data may be prepared in the form of graphical displays and briefing charts, or they may be generated during the conference, as notes, drawings, diagrams, or written material. The displayed data in a teleconference must be truly shared; a participant in a teleconference should be able to amplify or annotate the notes of another conferee, just as in a face-to-face conference where participants may make additions to the notes written on a blackboard.

1.3 The Concept of Virtual Space

Virtual Space refers to both a set of techniques for producing realistic video teleconferencing and the naturalistic rendition of spatial relationships among the participants of a teleconference produced by these techniques. This spatial representation gives the participants of a teleconference in Virtual Space the impression that they are at a face-to-face conference seated around a single conference table, although they are actually in separate locations, perhaps separated by many miles. When one conferee looks at another, all participants of the teleconference know who is being looked at.

The increased realism of Virtual Space is produced by three factors. First, the arrangement of the monitors corresponds to an arrangement which may occur at a traditional meeting: The monitors are spaced around a table rather than being lined up along a wall. Second, the arrangements at each teleconference station are consistent with a single spatial representation; that is, the relationships among the participants are the same at each participating terminal. Third, multiple cameras at each station give each participant the same viewpoint in the teleconference that he would have if he were present in a face-to-face conference. Section 2.0 discusses the techniques of Virtual Space in greater detail and describes some of the benefits produced by these techniques.

2.0 THE UTILITY OF VIRTUAL SPACE IN TELECONFERENCE

2.1 Meetings in Virtual Space

In this section, the techniques which produce Virtual Space are described. First, it is necessary to define the term "conferee surrogate" as the device which stands in for a conferee at a site where the conferee is not physically present. A conferee surrogate is a video display presenting the face of its corresponding remote conferee, together with a video camera and microphone, acting as the corresponding conferee's eyes and ears at that site.

The goal of the techniques developed in this research is to provide each participant with a convincing feeling of being present in a meeting room with the other participants arranged in a consistent and believable geometry, that is, Virtual Space. The concept of Virtual Space can be explained this way: Each participant must view the others in a "virtual" conference room (which they all "virtually" occupy) from the perspective of his own virtual location in that imagined room where all come together. The objective is to create as well as possible the illusion for each conferee that he is in this imagined location where all are together.

A Virtual Space teleconference system consists of three or more sites, each able to teleconfer simultaneously with as many other sites as it has conferee surrogates. For a four-party conference, each conferee or surrogate stand-in is at one corner of a square, as illustrated in Figure 2-1. The fact that this arrangement is a square is relatively unimportant. It is important, however, that the same arrangement exist at each location: A is always on B's left; B is always on C's left; and D is on A's left in every location.

Virtual Space

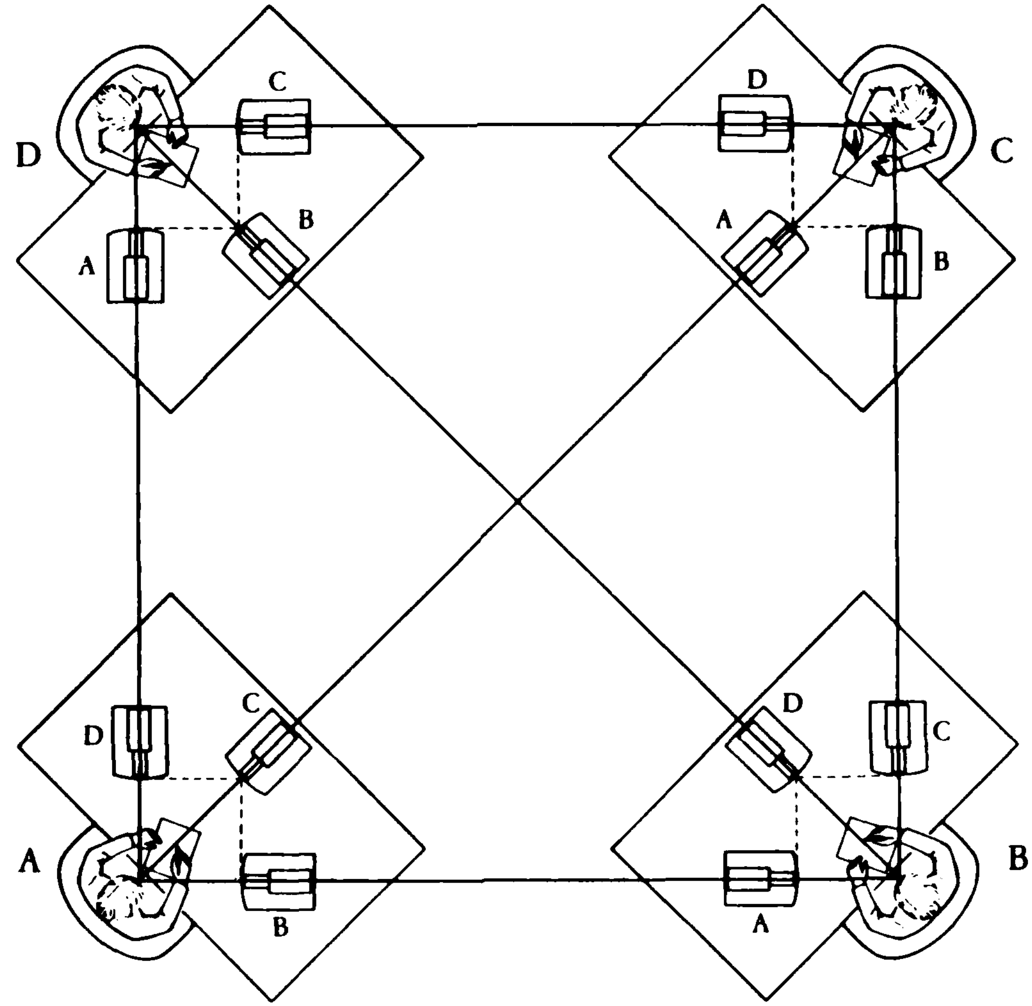

Fig. 2-1. Virtual Space

Consider the sites actively using the system at any given time. A position is defined as a spatial position which may be occupied either by a conferee or a surrogate. Each position in each site has a corresponding position in each other active site. Each has its "positions" arranged in a spatially similar arrangement: The angle from one position to another in any site is the same as for the corresponding positions in every other site. A pair of conferees and/or surrogates "correspond" if they occupy corresponding positions at different sites. Conferees never correspond; that is, two conferees never occupy corresponding positions.

Each conferee can view the other sites by viewing, face-on, one surrogate for each site, displaying the imagery from that remote site.

By using Virtual Space, a consistent spatial representation of a teleconference is maintained at each participating site, by focusing on each speaker from a different angle for each remote participant (necessitating twelve video cameras to connect four conferees in separate sites). For example, each of several offices seats one conferee at a round table of the same size, and the other seat-positions are occupied by conferee surrogates. A conferee surrogate may be a video monitor surmounted by a video camera, both pointed toward the conferee. The conferees or their matched surrogates are seated around each table, equally spaced, in the same order in each room. Each camera supplies video to the monitor of each of its matched surrogates, and each surrogate has a speaker reproducing the audio produced by the corresponding conferee.

If it were not vital to create a consistent virtual space to accommodate eye contact, gestural addressing, and demonstrative reference, teleconferencing would be simple: one frontally located video camera would be focused on each participant, and each would appear in the same full-face view to everyone else. Unfortunately, such an arrangement would distort the impression of realistic spatial relations to such a degree that social interaction would become unnatural and uncomfortable. For example, a speaker addressing the (virtual) participant directly opposite him would naturally be looking directly into a frontally located camera, and would thus appear to be looking directly not only at the addressee, but also at every other participant.

2.2 The Benefits of Virtual Space

Virtual space extends the state of the art in video teleconferencing by providing:

- face-on viewing of each surrogate monitor by each conferee;
- spatial reference, that is, a sense of physical presence and of space (someone on your right sees you on his left, and similarly for all viewing angles); and
- the same geometry of conferee A's image on conferee B's retina as if B were in B's corresponding position at A's site, and thus the ability to follow eye contact and gestural addressing and to see who is looking at whom.

It is hypothesized that giving each conferee his own station and the capability to follow group eye contact and direction of gaze creates a teleconference environment more similar to a face-to-face conference. Based on this hypothesis, we expect the Virtual Space concept to be more readily accepted than existing teleconference systems. The increased similarity to face-to-face meetings should remedy some of the defects of typical teleconference techniques, provide greater comfort and ease of discussion, reduce bias to meeting outcomes, support task performance roughly as well as face-to-face meetings, and provide conferees confidence in their existing communication skills and in meeting results.

Experimental verification of the hypotheses above must consider the fact that the benefits of Virtual Space will be most noticeable for certain types of groups and tasks. Specifically, the benefits would be expected to be greater for long-term users of the system than for naive users, and greater for larger groups than for smaller groups. Tasks for which Virtual Space would be most beneficial are those for which nonverbal cues provide information vital to successful performance of the task. Examples of such tasks would be complex problem solving, negotiations, resource allocation among divisions, and crisis management tasks. In areas such as these, Virtual Space would be expected to lead to better and more efficient performance.

2.3 Testing the Concept

In order to verify the benefits of Virtual Space teleconferencing, and to demonstrate the feasibility of the concept, DDI has built a Virtual Space teleconference system. A teleconference station accommodating one conferee and three conferee surrogates was installed in each of four DDI offices. These stations were connected to a central control station and to each other with coaxial cable. By incorporating the equipment into existing offices, the users are permitted to habituate to the new facility, and to learn to interact with it as naturally as they now do with the telephone.

Graphical data are displayed to conferees on a Shared Graphical Workspace (SGWS) monitor. Input to the SGWS monitor comes from an overhead camera at each station, a video disk, or an IBM 4331 computer. The overhead camera is focused on an area of about four inches by six inches on the desk of each teleconference station. The inputs are mixed so that graphic data are shared among the conferees. Thus, one conferee may point to, annotate, amplify, or highlight the notes of another conferee or a display generated by a computer or video disk.

Each station was designed to fit into the particular office for which it was designed. Thus, there are several differences among the four stations in configuration, monitor size, special features, and cabinet design. Specifics of the design of the stations are given in Section 3.0.

3.0 THE VIRTUAL SPACE TELECONFERENCE FACILITY

3.1 Configuration of the Facility

Four interconnected offices were supplied with teleconference stations. The stations were constructed using foamboard, glass, and wood; they were equipped with standard video displays, cameras, video distribution equipment, and specially designed electronics for combining video images. The size and shapes of the offices, as well as the preferences of the users necessitated a different station design for each office. The differences in design were used to determine the effects of design features, such as monitor size, station quality, and color displays on teleconference effectiveness. The four stations are pictured in the following figures and are described below.

The station pictured in Figure 3-1 is in the largest office and has the most enhancements of the four stations. The conferee surrogates are 19-inch color monitors positioned at three corners of a square with a side of approximately eight feet. The conferee sits in a chair at the fourth corner of the square behind a small coffee table. The table contains the SGWS monitor, system controls, and the writing area imaged by the overhead camera. The SGWS monitor is a 9-inch color monitor recessed into the center of the coffee table. Only the video disk provides color input to this monitor; input from the computer and overhead cameras is monochromatic. System controls, consisting of three switches and associated volume controls, are located directly to the right of the SGWS monitor.

The additional monitor along the back wall in Figure 3-1 displays the SGWS in the event that more than one conferee is present in the office. The cabinet underneath this

Figure 3-1
TELECONFERENCE STATION WITH 19-INCH COLOR CONFEREE SURROGATE MONITORS

monitor houses an optical video disk and computer video-disk controller using the spatial database management system (SDMS)(Negroponte, 1979). The video disk may also be controlled directly using the controller on the table beneath the system control switches.

The design of the station depicted in Figure 3-2 is quite similar to that of a conference room. The conferee surrogates, 12-inch monochrome video monitors, are located on pedestals around a conference table, again at the points of a square. The monochrome SGWS monitor was recessed into the table directly behind the writing surface. Controls are shown in the figure to the right of the SGWS monitor, directly above the conferee's left shoulder.

The stations shown in Figures 3-3 and 3-4 were designed so that all elements of the station are in a single cabinet (with the exception of the overhead camera, which was mounted in the ceiling). These designs involve slight distortions of the angular relations from those required by Virtual Space. Black-and-white monitors are considerably smaller than those in the previous designs, having diagnonal measurements of five inches and three inches for Figures 3-3 and 3-4, respectively. The SGWS monitor is positioned as in Figure 3-2; the control switches and writing surface are hidden in Figure 3-3 but clearly shown in Figure 3-4.

3.2 Operation of the System

The system was designed for simple operation. Controls consist of a set of switches used to call other conferees and a set of volume controls to adjust audio level for each remote conferee. In addition to these controls, red indicator lights indicate to each station when it is being called by another station.

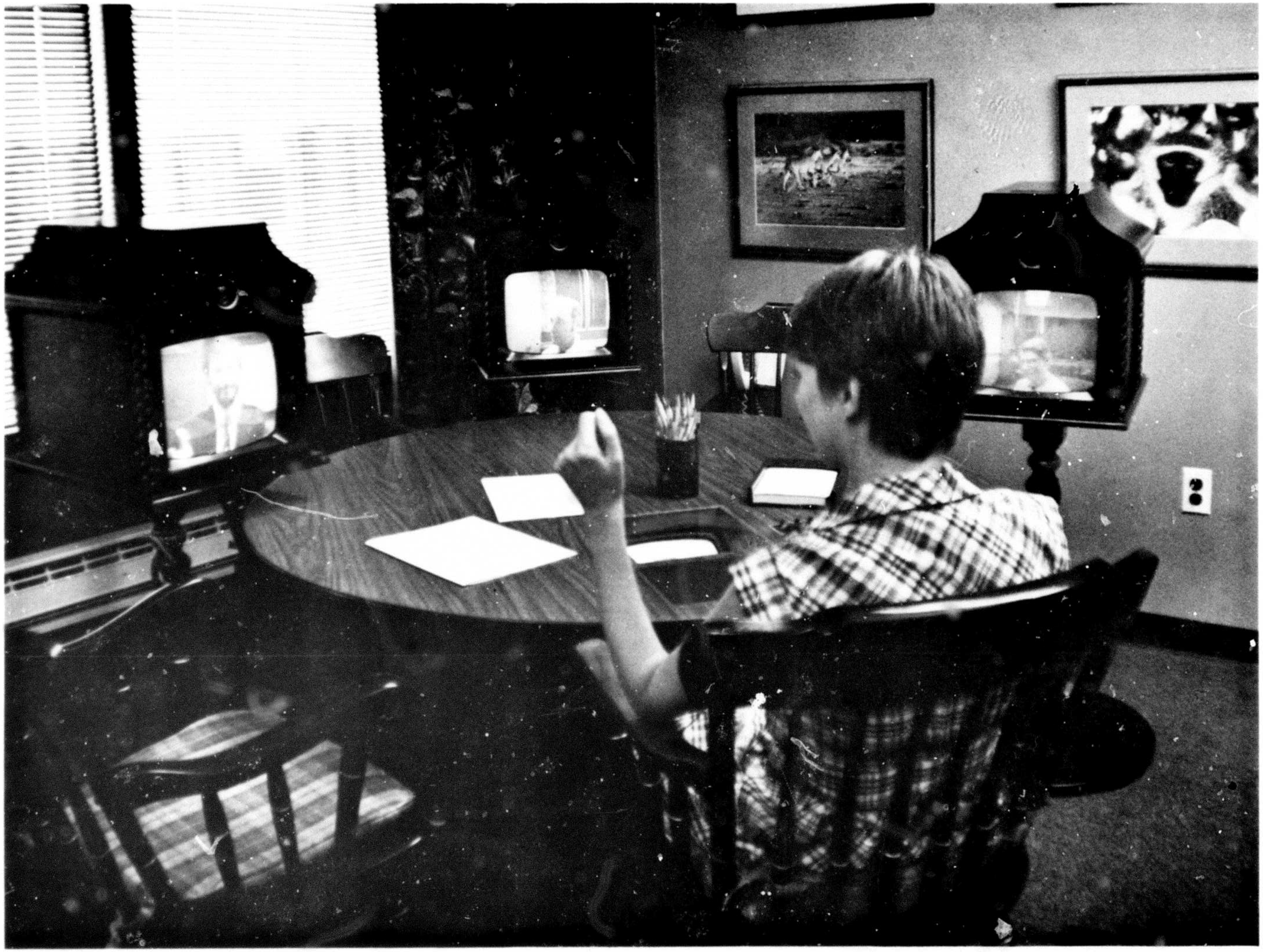

Figure 3-2
TELECONFERENCE STATION WITH 12-INCH BLACK & WHITE CONFEREE SURROGATE MONITORS

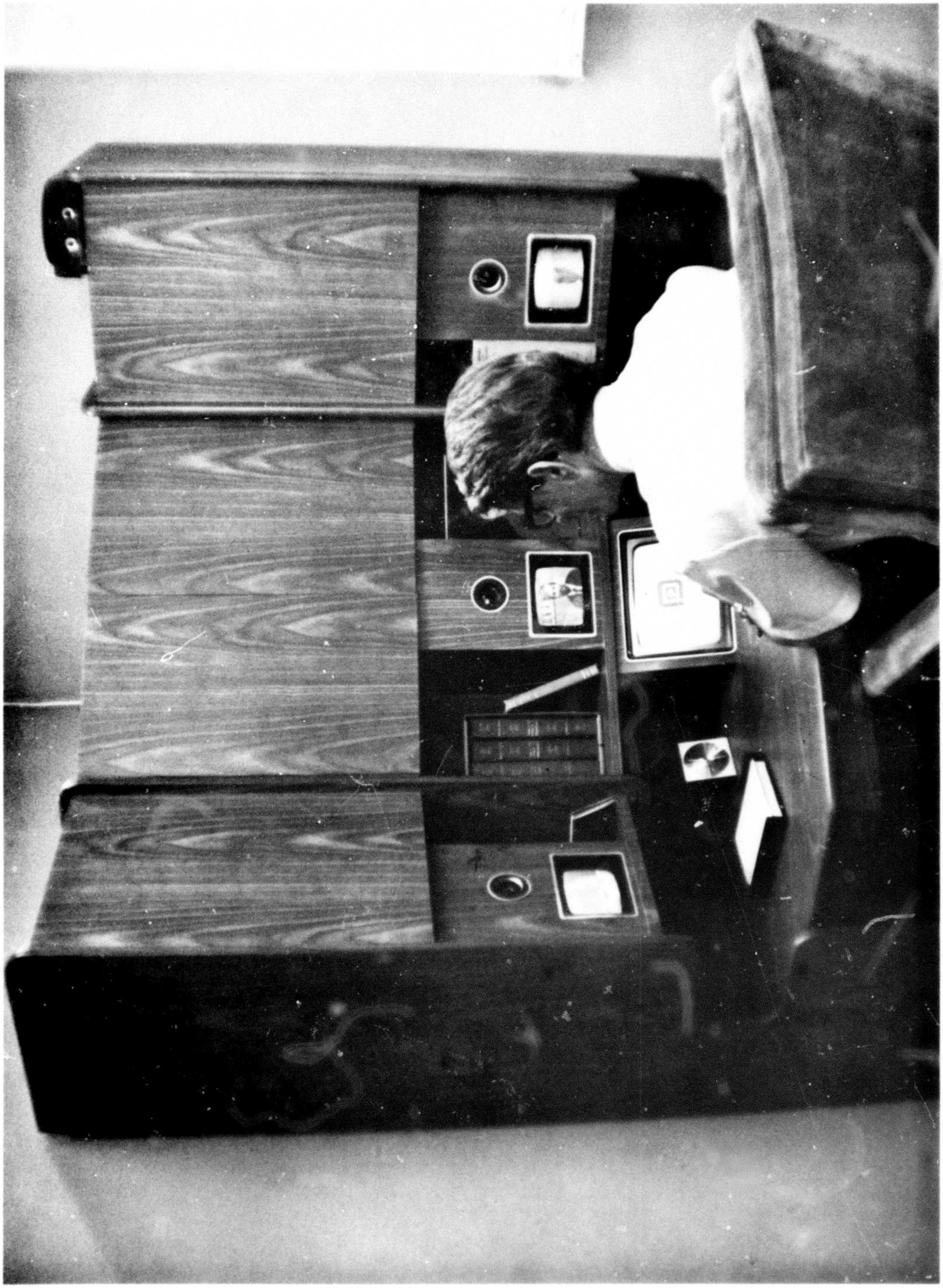

Figure 3-3
TELECONFERENCE STATION WITH 5-INCH BLACK & WHITE CONFEREE SURROGATE MONITORS

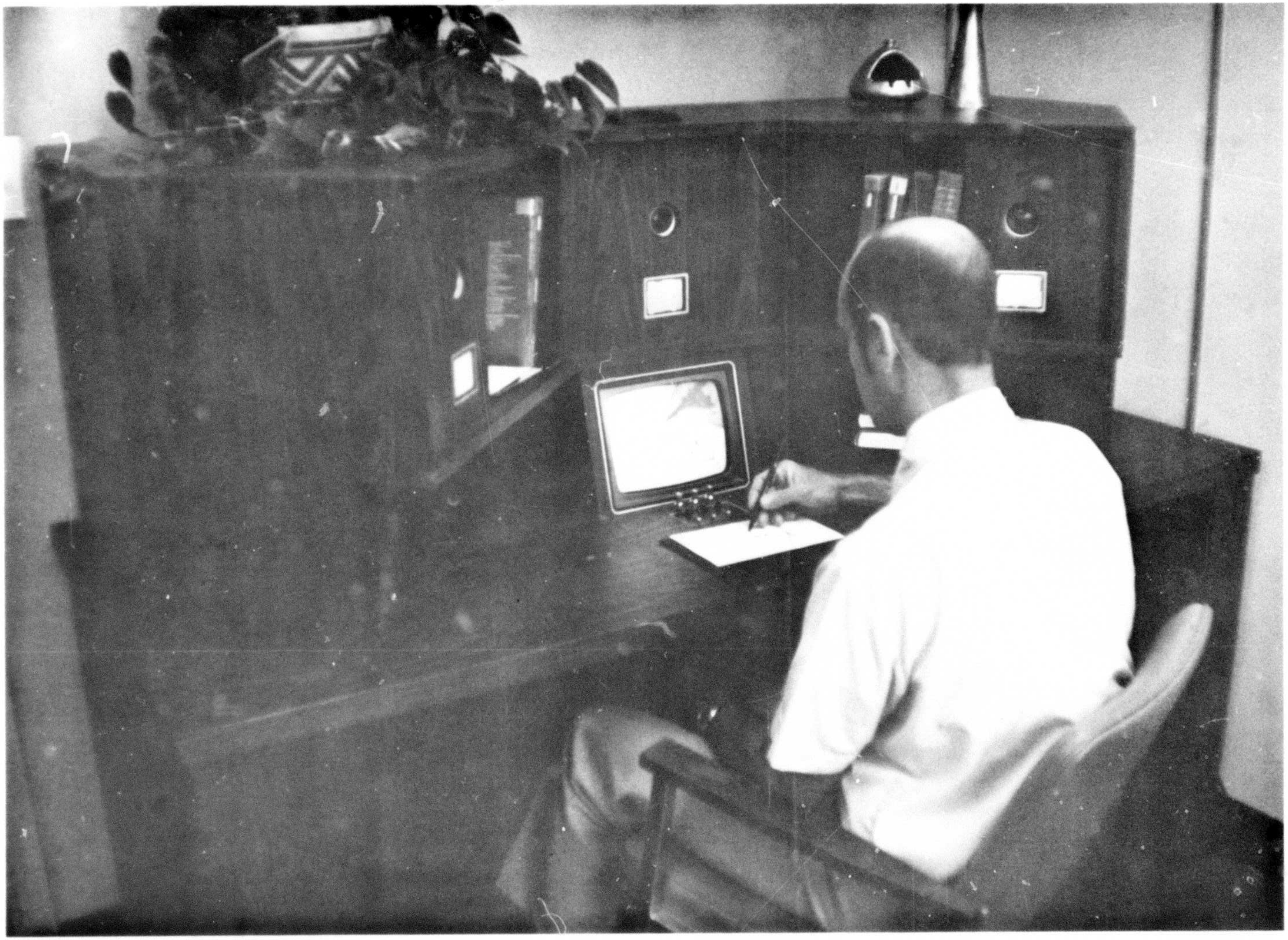

Figure 3-4
TELECONFERENCE STATION WITH 3-INCH BLACK & WHITE CONFEREE SURROGATE MONITORS

Each person callable from a station is represented by an on-off switch, labeled with his name. The switches are on the surface in front of the conferee; to initiate a teleconference, the conferee turns on the switches next to the names of those he wishes to call. In each of these stations, a short, pleasant tone is sounded once, and a red light is illuminated behind the switch with the caller's name. Turning on this switch answers the caller; otherwise, no connection is made.

If conferee A calls conferee B and is answered, and C calls D and D answers, two separate, private conferences are held. In the current implementation, the SGWS is shared among all four conferees, so graphical data are not private. If two conversations have a common conferee, audio can pass through his office from one conference to the other, and there is privacy only for facial video. Thus, the system has a limited capability to maintain private subconferences within a conference. It is also possible for conferees to pass private notes by placing them up to one surrogate's camera out of sight of the others.

3.3 User Response

The system was demonstrated to a large number of individuals from the military and from industry. Some were high-ranking military personnel or corporate executives who would be likely users for such a system; others were communications experts involved in research in teleconferencing. The overall response from these individuals was positive. Many reported that Virtual Space provided for natural communication over the system. Others gave suggestions for system improvements, some of which were incorporated into the system design. The general impressions of users are summarized in Section 4.0, along with other details of the system evaluation.

4.0 SYSTEM EVALUATION

The concerns in assessing the effectiveness of video teleconferencing with Virtual Space comprise two general areas. The first area is the quality of teleconferenced meetings. This concern reflects the desire that teleconferenced meetings be as natural as face-to-face meetings and that relevant data be immediately available to participants in teleconferences. The second area of concern is the overall operability of the system, including the convenience with which meetings may be called, the ease of operation of the system, the confidence in meeting privacy, and such factors as flexibility, reliability, and design attractiveness.

Several sources of information were used in assessing system effectiveness. Past research in the social-psychological literature of telecommunications provides a context for the current evaluation. This literature is briefly reviewed in Sections 4.1 and 4.2; extensive reviews are available elsewhere (Short, Williams, & Christie, 1976; Williams 1977). In addition, specific information was obtained about the current system from three sources: the comments of the users while the system was being installed, the comments of some of the many individuals to whom the system was demonstrated, and a multi-attribute utility evaluation of the system by its principal users.

The evaluation effort did not involve controlled experimental manipulations of the system configuration. Such evaluations would be premature at this early stage of development. Nevertheless, the data that were collected, although informal, provided a rich source of information from the impressions of a reasonably large number of people. The results described in Section 4.3 through 4.5 provide valuable insights for determining the benefits of future system enhancements.

4.1 Review of Previous Research

The psychological evaluation of telecommunications is a relatively new field of investigation. Consequently, the literature provides an incomplete picture of communication using various communications media. Investigators have extended some of the traditional methods of group dynamics and interpersonal communications research to study characteristics of and differences among media. There has been little investigation of the effectiveness of different ways of transmitting data (that is, electronic blackboard, facsimile reproduction, or computer terminal transmission). The literature is also limited in both the realism of the group meetings investigated and the variety of problems addressed by the groups under investigation. Naturally, none of the video teleconference systems investigated have offered the conference realism provided by the Virtual Space concept.

However, even at this early stage, the research offers some useful information for system design and evaluation. First, by establishing a context for the present evaluation effort, the research provides both a test for the face validity of the current evaluation and standard against which these results may be compared. Second, the literature indicates the types of conferences for which the realism provided by Virtual Space will be most beneficial. Finally, certain research findings are relevant to the current effort; some of these results are discussed below.

One of the major research strategies in the social psychology of telecommunications has been to compare group process and productivity between face-to-face groups and teleconferences with varying degrees of realism. Conference realism may be considered a unidimensional variable with face-to-face conferences on the high end, followed by Virtual Space teleconferencing, other video teleconferencing, audio teleconferencing, written messages, and possibly other communications media as well. Thus, although virtual space was not investigated directly, it will be possible in some cases to make inferences about the effectiveness of teleconferencing in Virtual Space.

Many of the results in the psychological evaluation of telecommunication can be summarized by the following four major findings:

- For a large variety of tasks, which may be described as primarily cognitive, there are no discernible differences in the productivity of face-to-face groups, audio-visual teleconferencing, and audio teleconferencing.

- Communication in the relatively rich media of face-to-face and audio-visual conferencing is qualitatively different from communication in audio teleconferencing.

- Degrading the realism of a conference reduces the influence of group structure on the decision. Also, certain teleconference configurations may change group structure, for example, by leading to the formation of coalitions.

- Users have a consistent preference for more realistic media. In particular, they prefer audio-visual teleconferences to those providing audio communications alone.

The research findings which form the basis of these general conclusions are described in the following section.

In addition to the research specifically addressing telecommunication, other research relevant to video teleconferencing has been conducted in the fields of communication and social psychology. Of particular interest is research on eye contact and other nonverbal behavior. Experiments have shown that being able to observe direction of gaze is of profound importance to interpersonal communication with respect to likability, group formation, leadership emergence, greetings and farewells, sequence of speech, personality differences, and so forth. These experiments have been extensively reviewed by Argyle and Cook (1976) and will not be described here. Research in nonverbal communication is reviewed by Duncan (1977). The results of research in these areas provide much of the justification for Virtual Space and other methods to increase the realism of video teleconference.

4.2 Specific Findings of Previous Research

4.2.1 Task performance - Experimenters have given groups of individuals a variety of problems to solve by communicating on audio-visual, audio, or data channels, or in face-to-face meetings. Although some of the problems solved were realistic management problems, others were of the somewhat artificial type often given in group problem-solving research (see Steiner, 1972). For a majority of problems investigated there was no difference in performance between face-to-face groups, audio-visual teleconferencing and audio teleconferencing.

For example, Chapanis, Ochsman, Parrish, and Weeks (1972) had two-person groups solve the problems of finding on a map the nearest physician to a given address and assembling a trash-can toter from instructions using one of four communications media: teletypewriting, remote handwriting, audio teleconferencing, and face-to-face meeting.

They found no performance or speed differences between audio and face-to-face groups, although there were differences between the written and oral groups. Champness and Davies (1971) also found no differences between audio and face-to-face groups on the solutions or satisfaction with the solutions for a human relations task.

Davies (1971) found similar results (i.e., comparable performance among the groups) on a simple learning task. In this task, subjects received information from either a typewriter, audio, audio-visual, or face-to-face channel. Subjects were then asked to recall the information and to indicate how confident they were in their recall. No differences were found among the conditions in the correctness of recall, the confidence of the subjects, or the response strategies used by the subjects.

The above studies used rather straightforward problem-solving or learning tasks with self-confirming correct answers. In a more open-ended brainstorming task. Williams (1975) found no differences in either the quality or the quantity of ideas produced by face-to-face teleconferenced groups in such a task.

The above studies indicate that for a variety of tasks, the addition of video information to audio, or even the addition of all information present in a face-to-face conference, does not significantly improve the performance on the task. However, for other tasks, particularly those involving bargaining or persuasion, video adds important information to that present in an audio channel. The nature of this difference is somewhat more elusive, though.

Short has conducted a series of experiments investigating the effects of communication medium on bargaining and negotiation (for a review of these experiments, see Short et al., 1976). These experiments examined the relative strengths of information and interpersonal factors in negotiations involving audio and audio-visual telecommunications as well as face-to-face groups. In one experiment (Short, 1974), subjects negotiated in pairs on a resource allocation problem. The situation was designed so that one subject took a position consonant with his beliefs, while the other subject took a position contrary to his beliefs. The person arguing his own opinions did better in the face-to-face and audio-visual condition, and worse in the audio-only condition. This result is consistent with earlier findings by Morley and Stephenson (1970) that evidence is more persuasive in audio-only communications, while interpersonal factors are more important in audio-visual and face-to-face conditions.

Other research has found that the communication medium induced differences in the behavior of individuals in a Prisoner's Dilemma game. For example, Wichman (1970) found more cooperation under conditions of audio-visual communication than conditions of audio communication alone. Laplante (1971) found that messages of positive or negative affect given during the course of a Prisoner's Dilemma game were more effective in an audio-visual medium than in an audio-only medium.

Although the research described above, as well as other related research, presents an incomplete and somewhat confusing picture of communication under different communication media, two conclusions may be made from these investigations. First, the visual channel does not provide much information useful to the solution of tasks which are primarily cognitive; these tasks can be adequately solved on audio channels. Second, the visual channel does provide a means for communicating affective and other interpersonal information. In a face-to-face group, this information is transmitted through facial expression, eye contact, body position, and body location. Video teleconferencing in Virtual Space allows the communication of facial expressions and eye contact. However, nonfacial kinesic and proxemic information is not transmitted by this system. The role of these sources of information remains to be discerned.

4.2.2 Differences in communication process - Although no differences between various communication media have been found in the performance of a variety of cognitive tasks, differences have appeared in the group communication process even in the same cognitive tasks. Various studies have found more and longer communications in face-to-face and visually mediated conferences than in aurally mediated conferences (Davies, 1971; Chapanis et al., 1972; Krueger, 1976). In addition, visual media seems to promote more coordinated conversation. Champness and Davies (1971) found a significant correlation on the time spent talking between the two participants in a video teleconference. No such correlation was found for audio teleconferences. These results, taken with the results concerning group performance, seem to indicate that visual communication gives information other than that necessary to solve cognitive problems. Some of this information may serve to control the interactions among group members.

4.2.3 Group structure - Research on the effects of electronically mediated communication has investigated two areas, emergent leadership and coalition formation. Strickland, Guild, Barefoot, and Paterson (1978) and Krueger (1976) have each found that the group structure is more egalitarian in teleconferences than in face-to-face groups. That is, the distribution of time spent talking and the number of messages sent is much more uniform in teleconferenced groups. Strickland et al. hypothesize that this difference is due to the lack of eye contact in video teleconferencing. Of course, Virtual Space offers a way to introduce eye contact into visually mediated communication. Whether the introduction of eye contact will restore more realistic leadership emergence remains to be seen.

The second area of investigation related to group structure concerns coalition formation. Williams (1975a) had groups of four subjects take part in a brainstorming task. Two subjects were placed in each of two rooms connected by a video teleconferencing link. The results indicate a strong tendency for individuals in the same room to form a coalition against the occupants of the other room. Ideas generated by one subject would tend to be supported by his roommate and refuted by the occupants of the other room. The subjective experiences of the subjects confirmed the results.

The effect of communication medium on group structure indicates that different media may be more or less appropriate for different tasks. In a brainstorming task, for example, differences in status or formal power may inhibit the ideas of low-status members. A medium which reduces the effect of status would improve idea generation. On the other hand, status differences may increase group productivity for decisions among well-defined alternatives. In these meetings, media which preserve group structure would be prefered. With teleconferencing, it may be possible to manipulate the degree of influence exerted by the formal group structure to obtain the most efficient interaction among group members.

4.2.4 Personal preferences - One finding revealed by many studies is that people prefer audio-visual communication to audio communication. Although, this result is an incidental finding in many studies, some researchers have directly investigated preferences for different communication media (e.g., Williams, 1957b; Champness, 1973). These studies have used methods including direct judgment of preferences and rating on semantic differential scales. The results confirm the attractiveness of video teleconferencing.

4.2.5 Summary - Although the literature presents an incomplete picture of the effectiveness of communication using video teleconferencing, some conclusions may still be drawn. First, the benefits of video teleconferencing are apt to depend on the task being performed. For strictly informational tasks, the video channel may not offer much increase in performance. For negotiations, the video channel may change the outcome to favor one party or the other. For tasks involving interpersonal knowledge and trust, a video channel may have a great deal to offer over audio communication channels. Second, there is an indication that the Virtual Space concept gives the capability for leadership more like that observed in face-to-face groups. This conclusion stems from the hypothesized effect of eye contact on emergent leadership. Finally, it is surprising how little research has been conducted on methods of communicating data. Many alternatives exist, such as fast facsimile, video channels, and electronic data tablets, but little research has been done on how these methods might affect the ability of the group members to process information, or the way information is communicated within the group.

The literature gives little information directly relevant to the evaluation of teleconferencing in Virtual Space. That evaluation comes from the impressions of the users of the system. The following sections decribe three sources of these impressions and the results obtained using each.

4.3 User Comments During Installation

The details of the design of the individual stations were changed many times to obtain a system that was most satisfactory for the users. Most of these changes were in response to particular areas of concern expressed by the system users; these concerns were recorded and the most important of them are summarized in this section. The concerns primarily involved problems relating to the integration of the teleconference system into the offices of the users. Problems which arose were in the areas of lighting, microphone convenience, resolution, audio level control, and assurance of privacy.

4.3.1 Lighting - A video teleconferencing system in an office must operate satisfactorily under ambient lighting conditions. The offices chosen for this implementation offered a variety of lighting conditions. One office had a unique lighting problem: two walls of windows facing south and west. Because the teleconference station was in the corner of the room opposite the windows, the afternoon and evening sunlight shone directly into the surrogate cameras. The effect of the backlighting made the conferee at this station appear almost as a silhouette to the other conferees. Closing the shades on all the windows was an inconvenient solution which posed other problems. With the shades closed, there was very little light on the face of the conferee at this station, and it was difficult to see facial features, particularly the eye area.

Several solutions to the lighting problem were attempted, including high-backed chairs to block out the light from the windows and auxiliary lights to light up the conferee's face. These solutions were only partially successful. Although it was finally determined that the installation of a curtain around the teleconference station combined with the use of auxiliary lights would solve the problem for this office, the solution was not implemented. It should be kept in mind that this office presented a unique and extreme lighting problem. Problems in other offices were comparatively minor and easily solved.

4.3.2 Microphone convenience - The system was initially installed using small clip-on microphones. These proved to be somewhat of an inconvenience, and the wires tended to get tangled up with chairs or feet, or interfered with the SGWS. As alternatives, both wireless microphones and directional microphones were tried. Each of these had some advantages and disadvantages over the original microphone. It was felt that a high-quality microphone, either wireless or directional, might prove superior to the clip-ons. However, a substantial investment must be made to obtain this higher quality.

4.3.3 SGWS resolution - The resolution goal for the SGWS was to be able to read a standard typed page of about six-inch width. This resolution is near the limit of that possible from a standard video monitor. When the system was first installed, it was impossible to read a standard typewritten page. However, adjustments to the system brought about satisfactory performance in this area. In addition, there was some difficulty in mixing the signals from the four stations with the video disk output. A video blender was installed to solve this problem.

4.3.4 Audio level control - The system was designed to have a minimum number of controls for the users. The initial design had only switches by which one user could initiate a conference. After the system was used for a while, it became clear that individual volume controls were necessary in the stations. These were needed because different people placed the microphones different distances from their faces, and listeners had different preferences for volume of others' voices. Installation of the controls solved all problems in this area without undue increase in operational complexity.

4.3.5 Assurance of privacy - There were concerns about privacy for two reasons. First, there was the possibility that conferences could be monitored at the central control station. Second, there was the possibility that conversations could be overheard because they are broadcast from speakers at the stations, rather than through an earpiece as in a telephone. A procedure was developed to ensure that individuals at the control center could not monitor conferences without knowledge of the conferees. This procedure satisfied the concerns of the users, and the addition of volume controls helped to solve the other part of the problem.

4.4 System Demonstrations

The system was demonstrated to a variety of individuals from business, military, and research organizations. The visitors often had comments about their impressions of the system. These comments were collected since many of them suggested ways to improve the system design. After the system was in its final form, a more formal method for recording the impressions of visitors was developed. The visitors were given the card shown in Figure 4-1 which asked six questions relating to their impressions of the quality of the teleconference system. The questions were designed to cover the general areas of the system about which visitors would likely have an opinion. In addition, questions were designed so that visitors could answer them after participating in a fifteen-minute demonstration.

Four of the areas covered concerned meeting effectiveness: oral information quality, effective data presentation, human image presentation, and conference realism. The capability of the teleconference system was scored for these

Name ____________________ **Date** ____________________

Office: RANDALL

Please evaluate the teleconference system by marking the appropriate location on each scale below. Additional comments on the reverse side of this card are welcome.

	GOOD AS TELEPHONE CONFERENCE										GOOD AS FACE-TO-FACE CONFERENCE
ORAL INFORMATION QUALITY											
EFFECTIVE DATA PRESENTATION											
HUMAN IMAGE PRESENTATION											
CONFERENCE REALISM											
	0	10	20	30	40	50	60	70	80	90	100

	MUCH WORSE					FACE-TO-FACE CONFERENCE					MUCH BETTER
CONFIDENCE IN PRIVACY											
CONVENIENCE											
	-50	-40	-30	-20	-10	0	10	20	30	40	+50

Figure 4-1

VISITOR QUESTIONNAIRE CARD

four factors on a scale from 0 to 100 in which 0 represented the capability of a telephone conference and 100 represented the capability of a face-to-face conference. The other two questions related to system factors, namely, confidence in privacy and convenience. Scores in these areas depend on the particular application for which the system is being used, that is, the distances between the stations and whether the information was encrypted. The visitors were asked to assume that the stations were located in separate cities and that data were sufficiently encrypted so that privacy of the transmission was not a concern.

The mean responses of the visitors to the questions to each teleconference station are presented in Figures 4-2 and 4-3 for the meeting quality and system factors, respectively. Error bars on these graphs represent the standard error of the mean. These bars are for descriptive purposes only. Because some visitors rated several stations and others rated only a single station, and because of the highly nonrandom sample of visitors who participated in a demonstration, statistical analyses are not appropriate for these data. In particular, only two people rated the station with 3-inch screens. Nevertheless, the error bars give an indication of the variability of the responses among different raters.

Figure 4-2 shows that the stations with larger screen sizes are rated higher in human image presentation and conference realism. In fact, the station with the 19-inch screens was rated nearly as high in these factors as a face-to-face conference (it should be kept in mind that the images were in color at this station). No such systematic differences appear in oral information quality and effective data presentation. The only difference in these factors appears in effective data presentation, for which the 12-inch station was rated lower. Several visitors commented

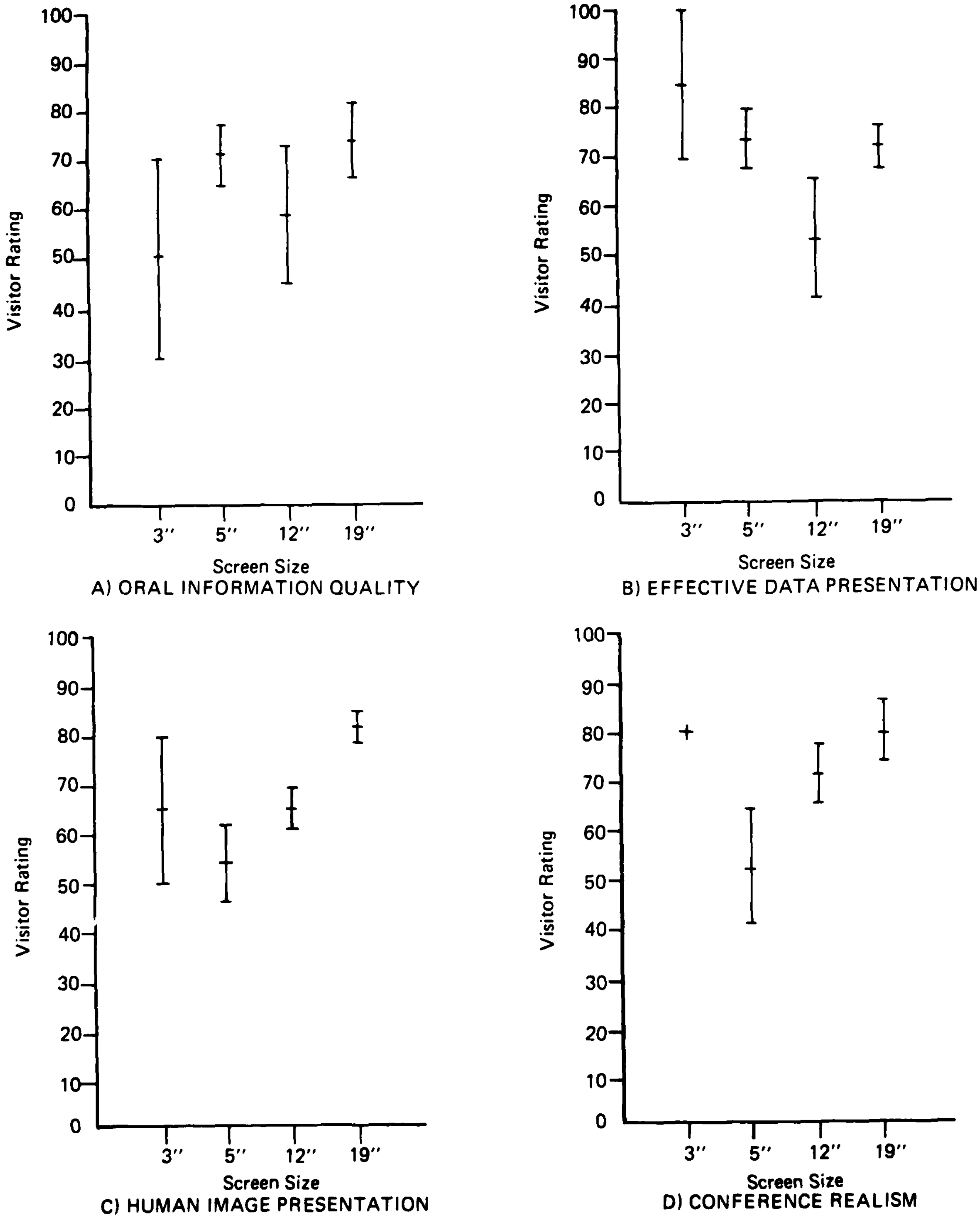

Figure 4-2

VISITOR RATINGS OF MEETING QUALITY FACTORS

00000037

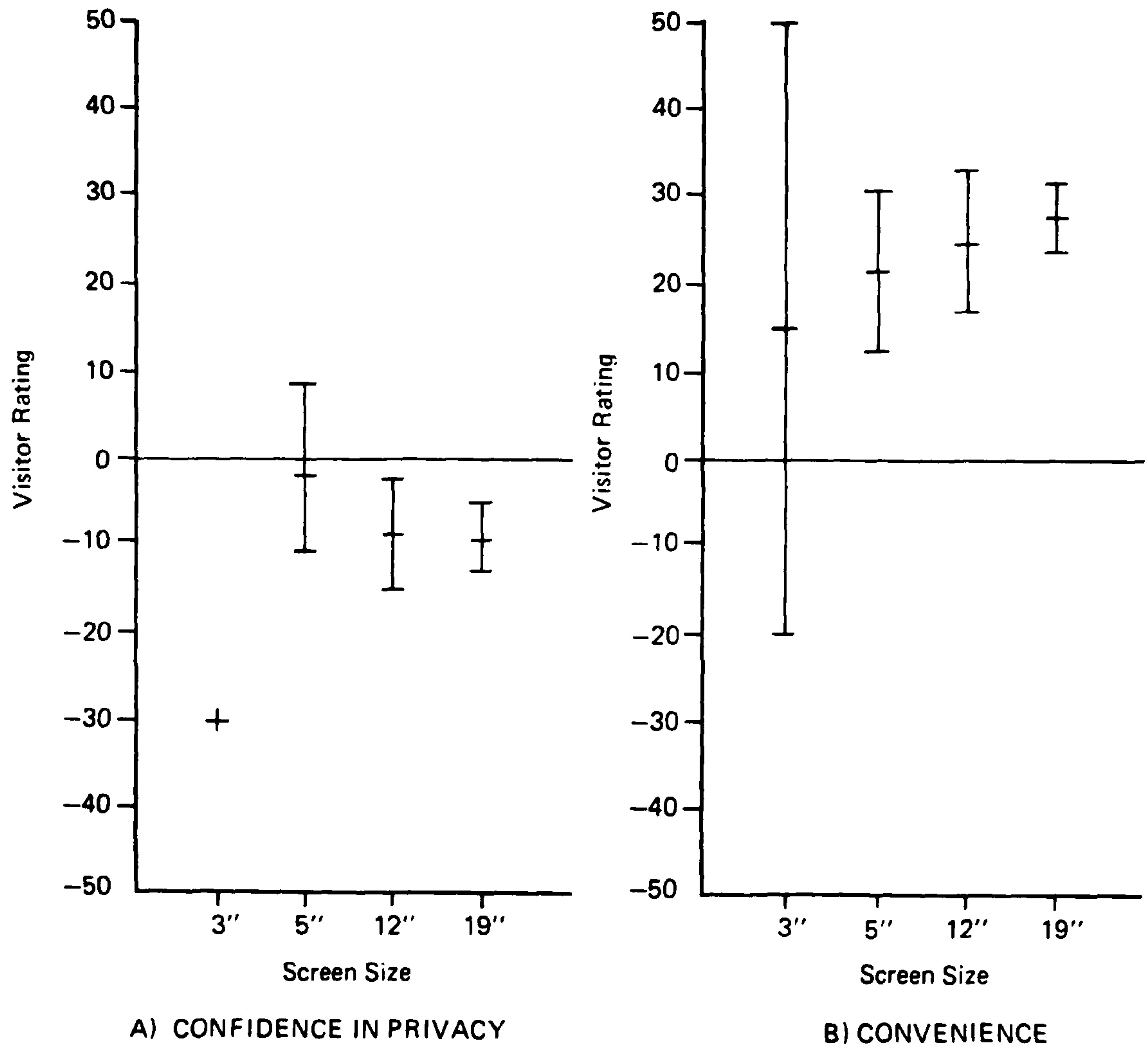

Figure 4-3

VISITOR RATINGS OF SYSTEM FACTORS

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that this problem may have been caused by a glare off the SGWS screen. Ratings for the 3-inch station do not fit any of the patterns; but because of the small sample size, the average ratings are not reliable, and conclusions were not based on them.

The ratings of the system factors in Figure 4-3 show no difference among the four stations. The visitors were slightly less confident in the privacy of the system than a face-to-face meeting; the average rating over all stations was -8.7 with standard error of the mean, 4.2. Visitors rated the system substantially more convenient than a face-to-face meeting; the average rating was 27.0 with standard error of 3.8.

4.5 Evaluation by Principal Users

The final method of evaluation of the teleconference system used a Multiattribute Utility Analysis (MAUA) developed during discussions among the princial users of the system. MAUA techniques are designed for the evaluation of fixed options that can be characterized as having levels on each of a number (potentially large) of attributes. The procedure involves scoring each of the options with respect to its level on each of the attributes and then assessing the relative importances of the inter-attribute differences among the options under evaluation. For each option, an aggregate score is calculated by weighting the option score on each attribute by the respective importance of that attribute and summing across attributes.

Specific analytic steps include:

1. Develop an evaluation structure -

    o Identify the options for evaluation.

o Identify attributes important to discriminating the values of these options.

o Structure the attributes in an evaluation framework--decompose general attributes into more specific attributes to yield an evaluation hierarchy.

Briefly, the procedure involves the development of a hierarchical evaluation structure that appropriately interrelates a comprehensive set of evaluation criteria. These criteria have the property that they are relevant to discriminating among the alternatives under consideration. It may be, for example, that a criterion is generally relevant to the facility evaluation issue, but that all the alternatives score similarly on that criterion. Such a criterion is either omitted initially or given a zero weight when it is later discovered to be of minimal relevance to the evaluation at hand.

2. Score the options on the attributes -

o Score each option with respect to each attribute.

o Perform a relative evaluation; that is, assign the option considered worst with respect to the attribute a score of 0--the best is scored at 100. The remaining options are given relative scores between 0 and 100 by comparing them with the 0 and 100 options, as well as with each other.

o Record rationale for all scores and enter it into the computerized evaluation mechanism.

After scoring all alternatives for all criteria, it is necessary to combine the separate scores into more general aggregate scores including an overall summary score. The more aggregate criteria form the higher level hierarchy factors and are a weighted combination of more specific sub-factors (criteria).

3. Assess inter-attribute importance weights -

- Assign the attributes <u>relative</u> importance weights. The weight assigned an attribute reflects the relative importance of the difference between the 0- and 100-point options on that attribute as compared to the importance of the 100-point differences on other attributes.

Criterion weights are developed that appropriately interrelate the 100-point ranges established for each criterion. (Recall that all criteria have a 100 percent range--worst to best.) The importance weight assigned a criterion reflects the increase in importance or benefit involved in "swinging" that criterion from its lowest level (worst alternative on that criterion) to its highest level (best alternative on that criterion). If criterion A receives a weight of 100 and criterion B a weight of 60, this means that the observed difference in benefit on criterion B is about 60 percent of that observed for criterion A. In this manner, all criteria are interrelated. Note that these weights can only be established after the scoring has been accomplished because the structure evaluates differences in alternatives. The weights for the bottom-level criteria in the structure--those for which scores are directly assigned--are normalized to sum to 100 points. These normalized weights are denoted as CUMWTS in the printouts. The weight of a higher level criterion equals the sum of the CUMWTS of the lower level criteria that compromise that criterion.

4. Compute aggregate scores for options -

   o Weight the score for an option on each attribute by the importance of the attribute. These weighted scores are summed to yield aggregate option scores.

5. Conduct sensitivity analyses -

   o Analyze the resultant aggregate scores to ensure the integrity of scores and weights. Evaluate the credibility of the results, and examine the sensitivity of the results to variations in scores. The rationale used to justify scores permits these scores to be challenged and modified and then supported by rationale that justifies the revised scores.

   o Conduct sensitivity analyses to determine the effects of variation in weights assigned. The importance weights assigned to different factors are varied through reasonable ranges to identify potential changes in decisions that might result from a possible uncertainty or disagreement about weights.

6. Draw conclusions--decision implications.

4.5.1 <u>Evaluation structure</u> - The evaluation up to this point has considered two components of teleconferencing utility: meeting quality and system factors. However, system factors may be construed as the performance of the facility in certain types of meetings. For example, confidence in privacy may be seen as the performance of the system in meetings of a sensitive nature; convenience may be seen as the flexibility of the system to perform in meetings which are not planned in advance. For this reason, the current analysis considered only factors of meeting quality for various types of meetings. However, the meeting types were developed to allow the assessment of important system factors as well.

The classification of meetings began with the functions described by Pye, Champness, Collins, and Connell (1973). These functions were used as a starting point to illustrate the variety of meetings which might be held, but proved an inadequate representation of the meetings for purposes of this evaluation. Consequently, a new structure of meeting types was made which related more directly to the effectiveness of video teleconferencing. The structure is shown in Figure 4-4.

The main classification of meetings is whether they are organized, creative or ad hoc. Organized meetings are concerned with distributing or sharing information, or with solving well-defined problems. They are arranged in advance and may vary in the sensitivity of the subject and their graphic needs. The first split of organized meetings is by function: information giving, information sharing and problem solving. Information-giving meetings are either lectures in which there is little interaction among the participants or seminars in which interaction is greater. The seminars may be on topics of normal or high sensitivity. Finally, the meetings may have no graphics needs; they may use graphics which are prepared in advance; or they may need graphic material which is generated during the meeting.

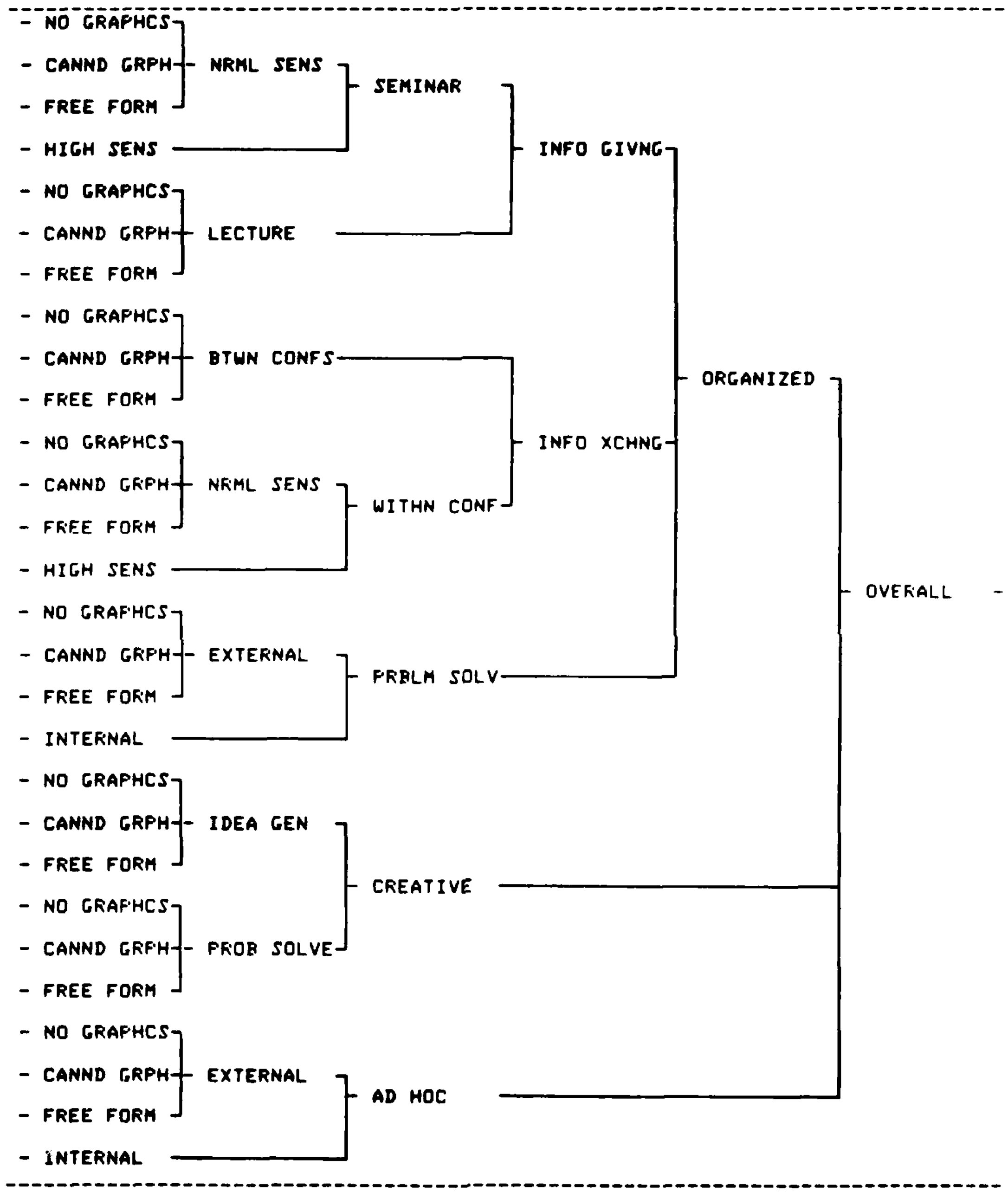

Figure 4-4

EVALUATION STRUCTURE FOR TELECONFERENCE SYSTEM

Information exchange may occur between groups of people or among several people within a single group. The between-group conferences were assumed to be of normal sensitivity; the within-group conferences could be of either normal or high sensitivity. Again, graphics needs could vary within one type of conference.

Problem-solving conferences could be concerned with an external problem, or the problem could directly involve one of the group members. Meetings solving internal problems with different graphics needs were not scored separately. The distinction of different graphics needs was made for meetings discussing external problems.

The second major type of meeting considered is the creative meeting. Creative meetings are principally concerned with the generation of ideas and solutions to ill-defined problems. For either of these types of problems, the graphics needs could be low or high.

Finally, ad hoc meetings are those which are not arranged in advance. The structure of ad hoc meetings mimics that of organized problem-solving meetings. Rating the quality of ad hoc meetings corresponds to rating the convenience of the system.

Three systems were rated in this evaluation, face-to-face meetings (denoted FF in printouts), an audio-only system similar to a telephone conference call (PHN), and a video teleconference system with Virtual Space (TVS). It was assumed that the teleconference stations were in different cities, and that telephone and teleconference systems were equivalently encrypted.

4.5.2 Assessed scores and weights - Assessed scores and weights are presented in Figure 4-5; rationale for the scores is presented in Appendix B. The scores are based on the expectations of the users derived from their knowledge of the system and of the types of meetings described in the structure.

4.5.3 Results - Figure 4-6 shows the overall scores for the systems at each level of the evaluation structure. Each matrix represents a single node in the evaluation hierarchy. For example, the first matrix in Figure 4-6 shows the score at the top level of the hierarchy; this is the overall score of the three systems. The table lists the three major components of the overall score, namely, organized meetings, creative meetings, and ad hoc meetings. The overall score is the weighted average of the scores on the three components with weights given in the column labeled "WT".

The next three columns give the scores of the three systems on each of the three components and the overall score. The overall scores indicate that teleconference performance is very nearly as good as that of a face-to-face conference. In fact, it is superior to both other systems in ad hoc meetings. In the other two meeting types, video teleconferencing with Virtual Space is about midway between the telephone and the face-to-face conference. The overall scores correspond closely to the ratings given by the visitors who saw the system. The first column to the right of the scores is a measure of discrimination which, for this analysis, is the same as the CUMWT. The CUMWT, which was explained earlier in this section, is displayed in the final column.

4.5.4 Discrimination analyses - The scores indicate the relative advantages and disadvantages of video teleconferencing with Virtual Space compared to telephone conferencing

NODE		WEIGHT	SYSTEM SCORE FF	PHN	TVS
0	- OVERALL	(WT:100)			
1	- ORGANIZED	(WT: 42)			
1.1	- INFO GIVNG	(WT: 19)			
1.1.1	- SEMINAR	(WT: 67)			
1.1.1.1	- NRML SENS	(WT: 59)			
1.1.1.1.1	- NO GRAPHCS	(WT: 8)	100	0	80
1.1.1.1.2	- CANND GRPH	(WT: 54)	100	0	90
1.1.1.1.3	- FREE FORM	(WT: 38)	100	0	80
1.1.1.2	- HIGH SENS	(WT: 41)	100	0	0
1.1.2	- LECTURE	(WT: 33)			
1.1.2.1	- NO GRAPHCS	(WT: 3)	100	0	80
1.1.2.2	- CANND GRPH	(WT: 57)	100	0	80
1.1.2.3	- FREE FORM	(WT: 40)	100	0	80
1.2	- INFO XCHNG	(WT: 33)			
1.2.1	- BTWN CONFS	(WT: 50)			
1.2.1.1	- NO GRAPHCS	(WT: 10)	100	0	50
1.2.1.2	- CANND GRPH	(WT: 50)	100	0	80
1.2.1.3	- FREE FORM	(WT: 40)	100	0	70
1.2.2	- WITHN CONF	(WT: 50)			
1.2.2.1	- NRML SENS	(WT: 59)			
1.2.2.1.1	- NO GRAPHCS	(WT: 10)	100	0	40
1.2.2.1.2	- CANND GRPH	(WT: 50)	100	0	70
1.2.2.1.3	- FREE FORM	(WT: 40)	100	0	70
1.2.2.2	- HIGH SENS	(WT: 41)	100	0	0
1.3	- PRBLM SOLV	(WT: 48)			
1.3.1	- EXTERNAL	(WT: 80)			
1.3.1.1	- NO GRAPHCS	(WT: 13)	100	0	75
1.3.1.2	- CANND GRPH	(WT: 25)	100	0	55
1.3.1.3	- FREE FORM	(WT: 63)	100	0	35
1.3.2	- INTERNAL	(WT: 20)	100	0	90
2	- CREATIVE	(WT: 33)			
2.1	- IDEA GEN	(WT: 43)			
2.1.1	- NO GRAPHCS	(WT: 28)	0	100	30
2.1.2	- CANND GRPH	(WT: 3)	0	100	30
2.1.3	- FREE FORM	(WT: 69)	100	0	70
2.2	- PROB SOLVE	(WT: 57)			
2.2.1	- NO GRAPHCS	(WT: 13)	100	0	80
2.2.2	- CANND GRPH	(WT: 25)	100	0	60
2.2.3	- FREE FORM	(WT: 63)	100	0	40
3	- AD HOC	(WT: 25)			
3.1	- EXTERNAL	(WT: 70)			
3.1.1	- NO GRAPHCS	(WT: 33)	0	80	100
3.1.2	- CANND GRPH	(WT: 11)	0	10	100
3.1.3	- FREE FORM	(WT: 56)	0	0	100
3.2	- INTERNAL	(WT: 30)	0	0	100

Figure 4-5

ASSESSED SCORES AND WEIGHTS

```
0   - OVERALL
      FACTOR          WT    FF  PHN  TVS    DISC1    CUMWT  FLG
  1)  ORGANIZED     ( 42)  100    0   56    41.67    41.67
  2)  CREATIVE      ( 33)   87   13   53    33.33    33.33
  3)  AD HOC        ( 25)    0   19  100    25.00    25.00
      TOTAL                 71    9   66   100.00   100.00

1   - OVERALL       - ORGANIZED
      FACTOR          WT    FF  PHN  TVS    DISC1    CUMWT  FLG
  1)  INFO GIVNG    ( 19)  100    0   60     7.94     7.94
  2)  INFO XCHNG    ( 33)  100    0   56    13.89    13.89
  3)  PRBLM SOLV    ( 48)  100    0   54    19.84    19.84
      TOTAL                100    0   56    41.67    41.67

1.1   - OVERALL     - ORGANIZED   - INFO GIVNG
      FACTOR          WT    FF  PHN  TVS    DISC1    CUMWT  FLG
  1)  SEMINAR       ( 67)  100    0   50     5.29     5.29
  2)  LECTURE       ( 33)  100    0   80     2.65     2.65
      TOTAL                100    0   60     7.94     7.94

1.1.1   - OVERALL     - ORGANIZED   - INFO GIVNG - SEMINAR
      FACTOR          WT    FF  PHN  TVS    DISC1    CUMWT  FLG
  1)  NRML SENS     ( 59)  100    0   85     3.11     3.11
  2)  HIGH SENS    *( 41)  100    0    0     2.18     2.18
      TOTAL                100    0   50     5.29     5.29

1.1.1.1   - ORGANIZED   - INFO GIVNG - SEMINAR     - NRML SENS
      FACTOR          WT    FF  PHN  TVS    DISC1    CUMWT  FLG
  1)  NO GRAPHCS   *(  8)  100    0   80      .25      .25
  2)  CANND GRPH   *( 54)  100    0   90     1.68     1.68
  3)  FREE FORM    *( 38)  100    0   80     1.18     1.18
      TOTAL                100    0   85     3.11     3.11

1.1.2   - OVERALL     - ORGANIZED   - INFO GIVNG - LECTURE
      FACTOR          WT    FF  PHN  TVS    DISC1    CUMWT  FLG
  1)  NO GRAPHCS   *(  3)  100    0   80      .08      .08
  2)  CANND GRPH   *( 57)  100    0   80     1.51     1.51
  3)  FREE FORM    *( 40)  100    0   80     1.06     1.06
      TOTAL                100    0   80     2.65     2.65

1.2   - OVERALL     - ORGANIZED   - INFO XCHNG
      FACTOR          WT    FF  PHN  TVS    DISC1    CUMWT  FLG
  1)  BTWN CONFS    ( 50)  100    0   73     6.94     6.94
  2)  WITHN CONF    ( 50)  100    0   39     6.94     6.94
      TOTAL                100    0   56    13.89    13.89
```

Figure 4-6

OVERALL SYSTEM SCORES

1.2.1 - OVERALL - ORGANIZED - INFO XCHNG - BTWN CONFS

FACTOR	WT	FF	PHN	TVS	DISC1	CUMWT	FLG
1) NO GRAPHCS	*(10)	100	0	50	.69	.69	
2) CANND GRPH	*(50)	100	0	80	3.47	3.47	
3) FREE FORM	*(40)	100	0	70	2.78	2.78	
TOTAL		100	0	73	6.94	6.94	

1.2.2 - OVERALL - ORGANIZED - INFO XCHNG - WITHN CONF

FACTOR	WT	FF	PHN	TVS	DISC1	CUMWT	FLG
1) NRML SENS	(59)	100	0	67	4.08	4.08	
2) HIGH SENS	*(41)	100	0	0	2.86	2.86	
TOTAL		100	0	39	6.94	6.94	

1.2.2.1 - ORGANIZED - INFO XCHNG - WITHN CONF - NRML SENS

FACTOR	WT	FF	PHN	TVS	DISC1	CUMWT	FLG
1) NO GRAPHCS	*(10)	100	0	40	.41	.41	
2) CANND GRPH	*(50)	100	0	70	2.04	2.04	
3) FREE FORM	*(40)	100	0	70	1.63	1.63	
TOTAL		100	0	67	4.08	4.08	

1.3 - OVERALL - ORGANIZED - PRBLM SOLV

FACTOR	WT	FF	PHN	TVS	DISC1	CUMWT	FLG
1) EXTERNAL	(80)	100	0	45	15.87	15.87	
2) INTERNAL	*(20)	100	0	90	3.97	3.97	
TOTAL		100	0	54	19.84	19.84	

1.3.1 - OVERALL - ORGANIZED - PRBLM SOLV - EXTERNAL

FACTOR	WT	FF	PHN	TVS	DISC1	CUMWT	FLG
1) NO GRAPHCS	*(13)	100	0	75	1.98	1.98	
2) CANND GRPH	*(25)	100	0	55	3.97	3.97	
3) FREE FORM	*(63)	100	0	35	9.92	9.92	
TOTAL		100	0	45	15.87	15.87	

2 - OVERALL - CREATIVE

FACTOR	WT	FF	PHN	TVS	DISC1	CUMWT	FLG
1) IDEA GEN	(43)	69	31	58	14.29	14.29	
2) PROB SOLVE	(57)	100	0	50	19.05	19.05	
TOTAL		87	13	53	33.33	33.33	

2.1 - OVERALL - CREATIVE - IDEA GEN

FACTOR	WT	FF	PHN	TVS	DISC1	CUMWT	FLG
1) NO GRAPHCS	*(28)	0	100	30	3.94	3.94	
2) CANND GRPH	*(3)	0	100	30	.49	.49	
3) FREE FORM	*(69)	100	0	70	9.85	9.85	
TOTAL		69	31	58	14.29	14.29	

Figure 4-6

OVERALL SYSTEM SCORES (Continued)

```
2.2  - OVERALL      - CREATIVE     - PROB SOLVE
     FACTOR          WT    FF  PHN  TVS    DISC1    CUMWT  FLG
 1)  NO GRAPHCS  *(  13)  100    0   80     2.38     2.38
 2)  CANND GRPH  *(  25)  100    0   60     4.76     4.76
 3)  FREE FORM   *(  63)  100    0   40    11.90    11.90
     TOTAL                100    0   50    19.05    19.05


3   - OVERALL      - AD HOC
     FACTOR          WT    FF  PHN  TVS    DISC1    CUMWT  FLG
 1)  EXTERNAL     (  70)    0   28  100    17.50    17.50
 2)  INTERNAL    *(  30)    0    0  100     7.50     7.50
     TOTAL                  0   19  100    25.00    25.00


3.1  - OVERALL      - AD HOC       - EXTERNAL
     FACTOR          WT    FF  PHN  TVS    DISC1    CUMWT  FLG
 1)  NO GRAPHCS  *(  33)    0   80  100     5.83     5.83
 2)  CANND GRPH  *(  11)    0   10  100     1.94     1.94
 3)  FREE FORM   *(  56)    0    0  100     9.72     9.72
     TOTAL                  0   28  100    17.50    17.50
```

Figure 4-6

OVERALL SYSTEM SCORES (Continued)

or face-to-face meetings. Figure 4-7 shows the scores of the systems on the directly scored nodes, ordered by the weighted algebraic difference between the teleconference score and the face-to-face conference score. This analysis indicates two major areas in which video teleconferencing is superior to face-to-face meetings, ad hoc meetings and creating meetings involving idea generating with some graphic needs. Face-to-face meetings, on the other hand, showed superiority in the meetings requiring graphical flexibility or concerning sensitive issues.

Figure 4-8 compares video teleconferencing to telephone conferencing. This analysis shows the clear superiority of the video system. In every area but one, the video system received a higher score.

4.5.5 Conclusions of evaluation - The evaluation has indicated several areas of strength for video teleconferencing with virtual space and has identified those areas in which more research is needed. Specifically, the current system offers many advantages over audio-only systems, and some advantages over face-to-face meetings in terms of convenience and performance in unstructured situations. Although these relative differences exist, past research indicates the need to examine the absolute level of the difference, especially as it relates to the cost of a video system.

A specific need for improvement of graphics capability was identified. Further enhancements of the capability of the system in this area could greatly increase its effectiveness; however, the present capabilities of the system fill the needs of many of its intended uses. In addition, methods to increase the security of the conferenced communication must be investigated. Further conclusions are presented in the following section.

	(WT)	FF	PHN	TVS	FLG	DISC2	SUM
3.1.3 - FREE FORM	(56)	0	0	100		9.72	9.72
3.2 - INTERNAL	(30)	0	0	100		7.50	17.22
3.1.1 - NO GRAPHCS	(33)	0	80	100		5.83	23.06
3.1.2 - CANND GRPH	(11)	0	10	100		1.94	25.00
2.1.1 - NO GRAPHCS	(28)	0	100	30		1.18	26.18
2.1.2 - CANND GRPH	(3)	0	100	30		.15	26.33
1.1.2.1 - NO GRAPHCS	(3)	100	0	80		¯.02	26.31
1.1.1.1.1 - NO GRAPHCS	(8)	100	0	80		¯.05	26.26
1.1.1.1.2 - CANND GRPH	(54)	100	0	90		¯.17	26.10
1.1.2.3 - FREE FORM	(40)	100	0	80		¯.21	25.88
1.1.1.1.3 - FREE FORM	(38)	100	0	80		¯.24	25.65
1.2.2.1.1 - NO GRAPHCS	(10)	100	0	40		¯.25	25.40
1.1.2.2 - CANND GRPH	(57)	100	0	80		¯.30	25.10
1.2.1.1 - NO GRAPHCS	(10)	100	0	50		¯.35	24.75
1.3.2 - INTERNAL	(20)	100	0	90		¯.40	24.36
2.2.1 - NO GRAPHCS	(13)	100	0	80		¯.48	23.88
1.2.2.1.3 - FREE FORM	(40)	100	0	70		¯.49	23.39
1.3.1.1 - NO GRAPHCS	(13)	100	0	75		¯.50	22.90
1.2.2.1.2 - CANND GRPH	(50)	100	0	70		¯.61	22.28
1.2.1.2 - CANND GRPH	(50)	100	0	80		¯.69	21.59
1.2.1.3 - FREE FORM	(40)	100	0	70		¯.83	20.75
1.3.1.2 - CANND GRPH	(25)	100	0	55		¯1.79	18.97
2.2.2 - CANND GRPH	(25)	100	0	60		¯1.90	17.06
1.1.1.2 - HIGH SENS	(41)	100	0	0		¯2.18	14.89
1.2.2.2 - HIGH SENS	(41)	100	0	0		¯2.86	12.03
2.1.3 - FREE FORM	(69)	100	0	70		¯2.96	9.07
1.3.1.3 - FREE FORM	(63)	100	0	35		¯6.45	2.62
2.2.3 - FREE FORM	(63)	100	0	40		¯7.14	¯4.52

Figure 4-7

DISCRIMINATION ANALYSIS OF TELECONFERENCING VS. FACE-TO-FACE CONFERENCES

	(WT)	FF	PHN	TVS	FLG	DISC2	SUM
3.1.3 - FREE FORM	(56)	0	0	100		9.72	9.72
3.2 - INTERNAL	(30)	0	0	100		7.50	17.22
2.1.3 - FREE FORM	(69)	100	0	70		6.90	24.12
2.2.3 - FREE FORM	(63)	100	0	40		4.76	28.88
1.3.2 - INTERNAL	(20)	100	0	90		3.57	32.45
1.3.1.3 - FREE FORM	(63)	100	0	35		3.47	35.92
2.2.2 - CANND GRPH	(25)	100	0	60		2.86	38.78
1.2.1.2 - CANND GRPH	(50)	100	0	80		2.78	41.56
1.3.1.2 - CANND GRPH	(25)	100	0	55		2.18	43.74
1.2.1.3 - FREE FORM	(40)	100	0	70		1.94	45.69
2.2.1 - NO GRAPHCS	(13)	100	0	80		1.90	47.59
3.1.2 - CANND GRPH	(11)	0	10	100		1.75	49.34
1.1.1.1.2 - CANND GRPH	(54)	100	0	90		1.51	50.86
1.3.1.1 - NO GRAPHCS	(13)	100	0	75		1.49	52.34
1.2.2.1.2 - CANND GRPH	(50)	100	0	70		1.43	53.77
1.1.2.2 - CANND GRPH	(57)	100	0	80		1.21	54.98
3.1.1 - NO GRAPHCS	(33)	0	80	100		1.17	56.15
1.2.2.1.3 - FREE FORM	(40)	100	0	70		1.14	57.29
1.1.1.1.3 - FREE FORM	(38)	100	0	80		.94	58.23
1.1.2.3 - FREE FORM	(40)	100	0	80		.85	59.08
1.2.1.1 - NO GRAPHCS	(10)	100	0	50		.35	59.43
1.1.1.1.1 - NO GRAPHCS	(8)	100	0	80		.20	59.63
1.2.2.1.1 - NO GRAPHCS	(10)	100	0	40		.16	59.79
1.1.2.1 - NO GRAPHCS	(3)	100	0	80		.06	59.85
1.1.1.2 - HIGH SENS	(41)	100	0	0		.00	59.85
1.2.2.2 - HIGH SENS	(41)	100	0	0		.00	59.85
2.1.2 - CANND GRPH	(3)	0	100	30		¯.34	59.51
2.1.1 - NO GRAPHCS	(28)	0	100	30		¯2.76	56.75

Figure 4-8

DISCRIMINATION ANALYSIS OF TELECONFERENCING VS. TELEPHONE

5.0 CONCLUSIONS AND RECOMMENDATIONS

This research has demonstrated the feasibility of a teleconference system providing for natural connection of more than two sites, usage of existing or easily obtained communication skills, and real-time examination of pictorial information and other data. Thus, the goals of this project have been met. Natural communication among more than two sites has been provided by using techniques of Virtual Space, which produces a naturalistic rendition of the spatial relationships among the participants in a teleconference. Data communication is provided by a shared graphical workspace which integrates images from overhead cameras at each site with video disk or computer output.

Users of the system have reported favorable impressions after demonstrations of teleconferenced meetings. Teleconferences were judged nearly as realistic as face-to-face meetings; data presentation was also judged very favorably. Teleconferences were rated substantially higher than face-to-face conferences in convenience. The results of a multiattribute utility assessment reflect the users' impressions; overall, the quality of meetings on the teleconference system was scored nearly as high as that of face-to-face conferences. Video teleconferencing was judged especially effective for ad hoc meetings and for meetings addressing internal problems.

In addition to these strengths of teleconferencing, two areas for further improvement were identified: security and graphics. Potential problems in security stem from the facts that voices are broadcast through a speaker rather than through an earphone, and that a conferee may not be able to see all the people present at another teleconference site. Also, for discussion of classified subjects, it will be necessary to encrypt both audio and video signals from each site. In the area of graphics, needs were identified for a larger area of coverage for the shared blackboard, necessitating a higher resolution graphics system; and for a greater variety of inputs to the graphics system.

The results of this project suggest areas in which further research would be beneficial. This research would investigate solutions to the problems of security and graphics, as well as considerations which arise when the system is enlarged to include a greater number of conferee surrogates or sites. Specific recommended areas for future research are briefly discussed below.

Although some of the problems of security can be solved procedurally or through small changes in equipment such as providing stereo earphones for audio transmission, discussion of classified topics requires encryption of both audio and video signals from each teleconference station. However, current encryption techniques cannot handle the data rate produced by full-channel video signals. Consequently, research is being carried out on methods of data compression of video images. Further research is necessary to evaluate the effectiveness of video teleconferencing with Virtual Space with reduced video bandwidth. In addition, the effects of various compression techniques on human perception should also be studied.

The two areas for improvement of the graphical display system involve providing larger area of coverage of the shared blackboard and additional inputs to the graphical system. Both of these enhancements increase the flexibility of the system; however, increased flexibility comes at the cost of more complicated control. Because of this complexity of operation, a staff member is required to perform the control functions under the direction of his superior so the principal conferees can communicate without technical encumbrance. Staff control makes it possible to obtain the full benefit of system flexibility. Research is necessary to integrate additional data sources and staff control into video teleconferencing with Virtual Space.

Finally, the effectiveness of enlarged video teleconference systems should be determined. The system may be enlarged by increasing the number of sites or increasing the number of surrogates within a site. Increasing the number of sites brings the benefits of teleconferencing to more people. However, the simple switching methods used for the current research are no longer adequate if the number of sites is increased greatly. Increasing the number of surrogates at a site makes larger conferences possible. In order to maintain the spatial arrangements of surrogates required by Virtual Space, each station must impose more on the office as the number of surrogates increases. Research in both areas of system enlargement is required to produce the most effective video teleconference system.

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Appendix A
RESEARCH ON TECHNOLOGY TRANSFER

APPENDIX A
RESEARCH ON TECHNOLOGY TRANSFER

The briefings given to Defense Nuclear Agency (DNA) personnel have been translated into a technology transfer. DNA and DARPA contractor personnel have visited a DNA facility and developed plans for making a surrogate travel "map". DNA will fund the effort. A briefing has been prepared showing the application of Spatial Database Management System (SDMS) technology to a variety of Navy problems of interest to the CNO.

A very successful half-day briefing was given to Lieutenant General P. X. Kelley, USMC, Commander of the Rapid Deployment Force (RDF). Topics covered included surrogate travel, SDMS, assessment of combat readiness, decision aids, and decision-analytic techniques that could be used to design the RDF. In a subsequent letter to the Director, DARPA, Lieutenant General Kelley stated his intent to follow up on all the above topics.

In late March, Dr. Kelly of DDI and Captain Hayes of DARPA briefed the NATO Military Committee at the request of General William Knowlton, USA, the U.S. Military Representative. The briefing, which covered surrogate travel, decision aids, teleconferencing, SDMS and assessment of combat readiness, was well attended by senior military personnel and their staffs. Follow-up briefings were given the next day to interested personnel on specific topics. Following the NATO briefings, similar presentations were given at Headquarters USEUCOM and at the component commands. From the comments obtained in response to these briefings, a need was identified for a derivative of surrogate travel which can provide maps and map-like data to military staffs. The development of this system, called MAPSTORE, is planned for inclusion in the FY 1981 CTD research program. A need was also identified for a new class of decision aids which would be cheap, easy to use, and fun. Specifications for such an aid have been outlined for a possible research program in FY 1981.

A decision analysis pilot application task was carried out in March at the request of a CIA Computer Applications Task Force to illustrate the application of decision-analytic techniques to a management problem. The work was accomplished at DDI over two days using the new decision conference format. Subsequent to this, an IBM 5110 computer and the decision-analytic model constructed at DDI were transferred to CIA for use in succeeding analyses and in briefing senior decision makers. According to reports from the CIA personnel, the decision conference was a resounding success and materially aided them in developing recommendations for CIA management. They anticipate that requests for additional analyses will follow as a result of their internal briefings.

Appendix B

ASSESSED SCORES AND RATIONALE

Appendix B

ASSESSED SCORES AND RATIONALE

1.1.1.1.1 - NO GRAPHCS	FF	PHN	TVS
	100	0	80

The main difference here is in the extent to which the presentation of information may be interrupted by people with questions or other comments. This facility is offered to the greatest extent in a face-to-face conference. Video teleconferencing offers a reduced capability in this area. In a telephone conference, interruptions would be difficult and confusing.

Since there are no graphics needs, it is possible to adequately transmit the information in either alternative.

1.1.1.1.2 - CANND GRPH	FF	PHN	TVS
	100	0	90

Because graphics are prepared in advance, it would be possible to put them in a format that is compatible with the teleconference shared graphic workspace. However, the resolution of the system would limit the amount of information that could be placed on a single graphic display. Format limitations would also be slightly detrimental.

A seminar of this type could be conducted on an audio only system if graphic material were distributed in advance.

1.1.1.1.3 - FREE FORM	FF	PHN	TVS
	100	0	80

The limited resolution (or equivalent small area of coverage) of the teleconference shared graphic workspace has a somewhat greater impact in free form graphics than in prepared graphic material.

On the other hand, a conference of this type would be nearly impossible to conduct on an audio only system.

1.1.1.2 - HIGH SENS

	FF	PHN	TVS
	100	0	0

A face-to-face conference offers the highest assurance of confidentiality.

Telephone conference offers somewhat lower confidentiality because of the possibility of obtaining the information during transmission. This task is probably easier to do with audio than with video signals. However, the video teleconference, the fact that the voice is broadcast into the room presents some problem with others either in or out of the room overhearing sensitive information.

1.1.2.1 - NO GRAPHCS

	FF	PHN	TVS
	100	0	80

The differences between the systems would probably be small. Face-to-face offers the closest contact between the lecturer and the listeners and hence the best performance. Video teleconferencing would be almost as good. A telephone conference would be worst in this respect.

1.1.2.2 - CANND GRPH

	FF	PHN	TVS
	100	0	80

The main disadvantages of video teleconferencing compared to face-to-face meetings in this area is the limited resolution and format of the shared graphic workspace. Because the graphics are prepared in advance, it would be possible to put them in a format compatible with the shared graphic workspace, but the resolution of the system would still limit graphical information content.

A lecture of this type could be conducted on an audio only system if graphic material were distributed in advance.

1.1.2.3 - FREE FORM

	FF	PHN	TVS
	100	0	80

The limited resolution (or equivalent small area of coverage) of the teleconference shared graphic workspace has a somewhat greater impact in the free form graphics than in prepared graphic material.

On the other hand, a conference of this type would be nearly impossible to conduct on an audio only system.

1.2.1.1 - NO GRAPHCS	FF	PHN	TVS
	100	0	50

A face-to-face conference offers the best alternative for this type of meeting.

A meeting on an audio only system would be quite confusing and very difficult to coordinate.

Video teleconferencing would offer a more organized meeting because of the visual cues used to coordinate the conversation. However, the current system would offer a somewhat crowded atmosphere at the individual sites.

1.2.1.2 - CANND GRPH	FF	PHN	TVS
	100	0	80

The limited resolution and single format of the teleconference shared graphic workspace leads to problems discussed in 1.1.1.1.2 and 1.1.2.2.

1.2.1.3 - FREE FORM	FF	PHN	TVS
	100	0	70

The limited resolution (or equivalent small area of coverage) of the teleconference shared graphic workspace has a somewhat greater impact in free form graphics than in prepared graphical material. In addition, it may be desirable to save a graphical display along with annotations made on the display from several users.

On the other hand, a conference of this type would be impossible to conduct on an audio only system.

1.2.2.1.1 - NO GRAPHCS	FF	PHN	TVS
	100	0	40

A telephone conference would be more easy to coordinate here than it would be in 1.2.1.1 (Between Conferences). Thus the differences between PHN and the other alternatives are somewhat reduced. TVS is also slightly improved, but it still receives a proportionately lower score.

1.3.1.2 - CANND GRPH

	FF	PHN	TVS
	100	0	55

The main disadvantages of video teleconferencing compared to face-to-face meetings in this area is the limited resolution and format of the shared graphic workspace. In addition both video and audio teleconferencing would be expected to be harder to control by the leader or organizer than face-to-face meetings.

1.3.1.3 - FREE FORM

	FF	PHN	TVS
	100	0	35

Both electronic communications media perform poorly relative to the face-to-face meeting in this area. This type of meeting would be nearly impossible on a audio only system.

Video teleconferencing is plagued by problems in resolution and format, as mentioned elsewhere. In addition, the system does not offer the opportunity to store graphical displays which have been changed or created dynamically during the course of the conference.

1.3.2 - INTERNAL

	FF	PHN	TVS
	100	0	90

Both media offering visual communication score high here. Visual communication provides information about affect, emotional state, and attitude which would aid in the solution to interpersonal problems.

2.1.1 - NO GRAPHCS

	FF	PHN	TVS
	0	100	30

Groups generally are not as good at generating ideas than individuals working alone. Thus the system which is least like a face-to-face group would offer the greatest performance in idea generation. Thus the telephone scores highest, followed by the video teleconferencing system and the face-to-face group.

1.3.1.2 - CANND GRPH

	FF	PHN	TVS
	100	0	55

The main disadvantages of video teleconferencing compared to face-to-face meetings in this area is the limited resolution and format of the shared graphic workspace. In addition both video and audio teleconferencing would be expected to be harder to control by the leader or organizer than face-to-face meetings.

1.3.1.3 - FREE FORM

	FF	PHN	TVS
	100	0	35

Both electronic communications media perform poorly relative to the face-to-face meeting in this area. This type of meeting would be nearly impossible on a audio only system.

Video teleconferencing is plagued by problems in resolution and format, as mentioned elsewhere. In addition, the system does not offer the opportunity to store graphical displays which have been changed or created dynamically during the course of the conference.

1.3.2 - INTERNAL

	FF	PHN	TVS
	100	0	90

Both media offering visual communication score high here. Visual communication provides information about affect, emotional state, and attitude which would aid in the solution to interpersonal problems.

2.1.1 - NO GRAPHCS

	FF	PHN	TVS
	0	100	30

Groups generally are not as good at generating ideas than individuals working alone. Thus the system which is least like a face-to-face group would offer the greatest performance in idea generation. Thus the telephone scores highest, followed by the video teleconferencing system and the face-to-face group.

2.1.2 - CANND GRPH

	FF	PHN	TVS
	0	100	30

The need for graphics is a factor in favor of face-to-face groups over the electronic communication media. Compensating for this advantage is the disadvantage of face-to-face groups in the quantity and quality of ideas generated. Resulting differences are small; scores indicate the latter consideration is slightly more important.

2.1.3 - FREE FORM

	FF	PHN	TVS
	100	0	70

The need for graphics in this case overcomes the loss in performance due to group effects.

The video teleconference system offers some capability in this area, although it is limited by the resolution, format, and lack of storage facility.

2.2.1 - NO GRAPHCS

	FF	PHN	TVS
	100	0	80

Performance is effected by the same factors as in 1.3.1.1 except that the leadership loss brought about by the electronic media is not as important in these more creative meetings.

2.2.2 - CANND GRPH

	FF	PHN	TVS
	100	0	60

The factors affecting these scores are the same as in 1.3.1.2, except that the control of the leader is not as important an issue here. Hence, the electronic systems do relatively better here.

2.2.3 - FREE FORM

	FF	PHN	TVS
	100	0	40

The factors leading to the scores here are the same as those in 1.3.1.3, except that the control of the leader or organizer is not an important consideration here.

3.1.1 - NO GRAPHCS

FF	PHN	TVS
0	80	100

Ad hoc face-to-face metings are impossible because of the geographic separation of the participants. Teleconference meetings are more convenient and of somewhat higher quality than audio conferences. Because of the low graphics needs, both electronic media would be adequate.

3.1.2 - CANND GRPH

FF	PHN	TVS
0	10	100

As in 3.1.1, face-to-face meetings are impossible. A telephone conference might be possible in some situations if relevant graphic information were telecopied to conferees while the meeting was being arranged. This approach would only be acceptable in situations in which the information required would be small.

3.1.3 - FREE FORM

FF	PHN	TVS
0	0	100

Video teleconferencing is the only system of the three with a potential for conducting ad hoc meetings requiring free form graphics.

3.2 - INTERNAL

FF	PHN	TVS
0	0	100

A face-to-face meeting would be preferred, but is impossible. An audio conference would be unacceptable. Video teleconferencing offers the only potentially acceptable solution.

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